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Dated 17 AUG 2000

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09JUL99 E460854-1 D02917
P01/7700 0.00 - 9916080.6

Patents Form 1/77
Patents Act 1977
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The Patent Office

Request for grant of a patent

The Patent Office
Cardiff Road
Newport
Gwent NP9 1RH

08 JUL 1999

1. Your reference
   1829801/AM

2. Patent Application Number
   9916080.6

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   Scientific Generics Limited
   Harston Mill
   Harston
   Cambridgeshire CB2 5NH

   Patents ADP number *(if known)* 5698874003

   If the applicant is a corporate body, give the country/state of its incorporation — Country: **ENGLAND**
   State:

4. Title of the invention

   INCREASED PACKING DENSITY

5. Name of agent — **Beresford & Co**

   "Address for Service" in the United Kingdom to which all correspondence should be sent — **2/5 WarwickCourt**
   High Holborn
   London WC1R 5DJ

   Patents ADP number 1826001

6. ~~Priority details~~

Country	Priority application number	Date of filing

7. If this application is divided or otherwise derived from an earlier UK application give details

Number of earlier of application | Date of filing

8. Is a statement of inventorship and or right to grant of a patent required in support of this request?

YES

9. Enter the number of sheets for any of the following items you are filing with this form.

Continuation sheets of this form	
Description	2
Claim(s)	
Abstract	
Drawing(s)	4 x4

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents form 7/77)*	**1 + 2 COPIES**
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for Substantive Examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application

Signature Beresford & Co
BERESFORD & Co

Date 8 July 1999

12. Name and daytime telephone number of person to contact in the United Kingdom

ALAN MACDOUGALL

Tel:0171-831-2290

Increased Packing Density

Background

The applicant has described in WO98/35328 an optical communication system employing a pixellated reflective modulator array combined with a telecentric optical system. The system operates by assigning each user of the system a unique pixel in the array. Each pixel in the array maps to a unique angular position in the field of view of the telecentric optical system (figure 1). The content of WO98/35328 is incorporated herein by way of reference.

In order that the field of view is fully covered (that is, that there are no gaps in the angular coverage), the pixels in the array must be contiguous, that is, there should be no gaps between the pixels. In practice, this is difficult to achieve, as small gaps are inevitable if the pixels are to electrically isolated, and if there is to be sufficient space to allow connections to the individual pixels. Our invention relates to methods by which the effective packing density can be made increased to 100%, using arrays with <100% packing density.

In a typical modulator array, each pixel may have a size of several tens of microns, but might typically be 30μm. The gap between pixels is set by the requirement to form electrically isolating mesas between the pixels. The gap size would be typically 5μm, leading to a packing density (by area) of ~73%.

Description of our invention

Our invention concerns the use of an additional optical element to increase the packing density of a practical modulator array to 100%.

According to the first aspect of our invention, we make use of an array of microlenses. The microlens array is fabricated such that the centres of the microlenses have the same grid spacing as the modulator pixel array. In this way, each microlens acts as an optical system for an individual modulator pixel shown in figure 2.

Each lens acts to form a magnified image of the associated modulator pixels, such that, when viewed from the exit pupil of the telecentric optical system, the array appears to have 100% packing density. By virtue of the Lagrange invariant of the optical system, the numerical aperture of beam at the modulator pixel with the microlens in place must be larger than without the lens by a factor equal to the linear magnification afforded by the microlens. In the case of the modulator array described above, the linear magnification required to achieve 100% packing is 1.167, and hence the numerical aperture at the pixel is increased by this factor. This is a relatively small increase in numerical aperture, and in most cases is well within acceptable limits for the modulator pixel.

According to the second aspect of our invention, we make use of two or more modulator arrays. Beamsplitting optics is used to divide the beams from the telecentic optical system between the modulator arrays.

Consider two arrays of the type described above. The arrays are mounted such that they are `out of register' by one half of the pixels pitch in both dimensions. This is shown schematically in figure four.

As may be seen, the packing density is significantly increased (in this case to ??%), but cannot equal 100% with only two modulators.

Modulator arrays may be constructed with a packing density of 25%, in which the gap between the pixels is equal to the pixels size, as shown in figure five.

By employing further beam splitters, four such array may be optically combined to achieve 100% packing density, as shown in figure 6.

It will be appreciated that in many applications, users of such a communication system will be distributed in substantially a horizontal plane, and in this case a linear array of modulator pixels is sufficient. In this case, on two such arrays are required to achieve 100% packing density, as shown in figure 7.

According to the third aspect of our invention, two of more telecentric optical systems and modulator arrays are employed. This aspect makes use of the fact that the beam incident upon the modulator system is typically significantly larger than the telecentric stop, and hence can be made to fill the spots of more than one telecentric system. The telecentric systems are offset in angle (shown in figure 8), such that the angular coverage of the pixels between different systems intermesh in a similar fashion to that described in the second aspect of our invention. This approach can achieve 100% packing density without the additional optical loss associated with beamsplitters, but at the cost of additional telecentric optical systems.

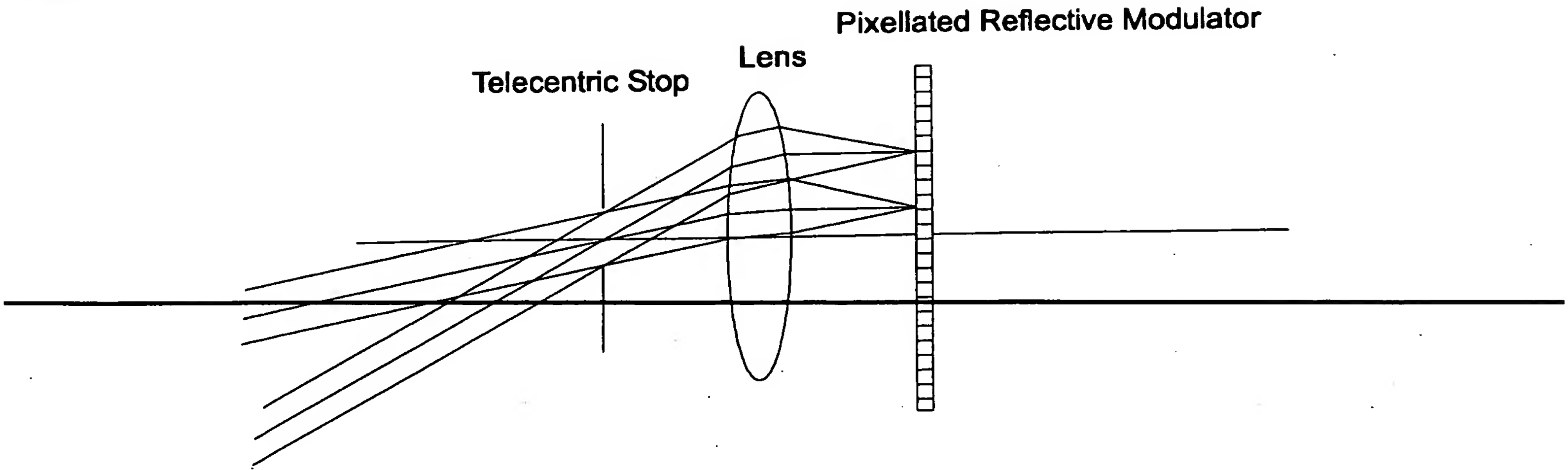

Figure 1

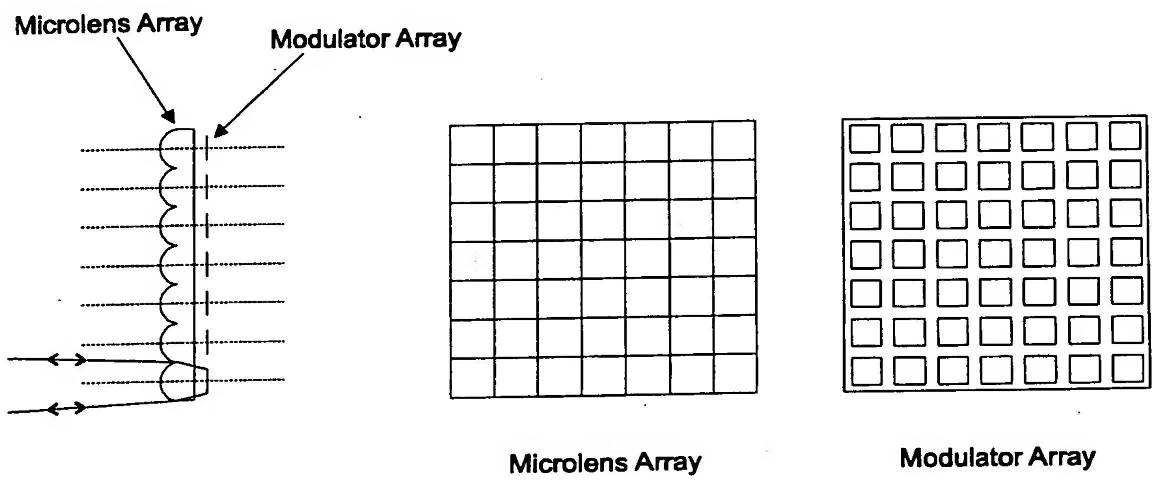

Figure 2

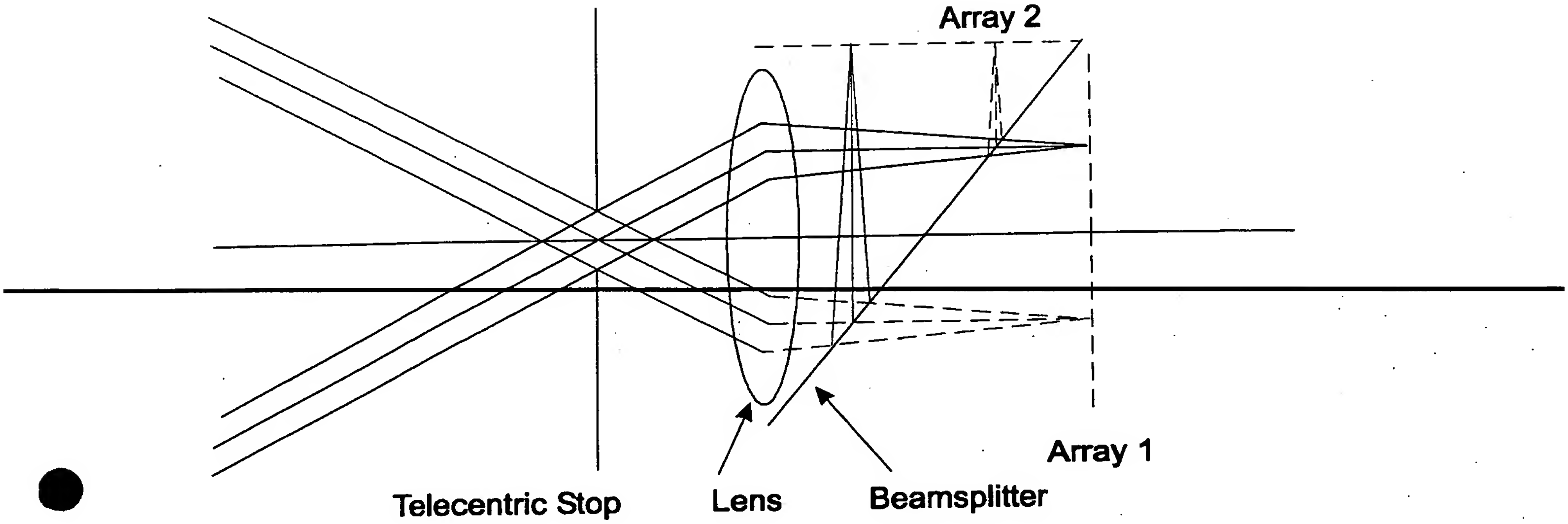

Figure 3

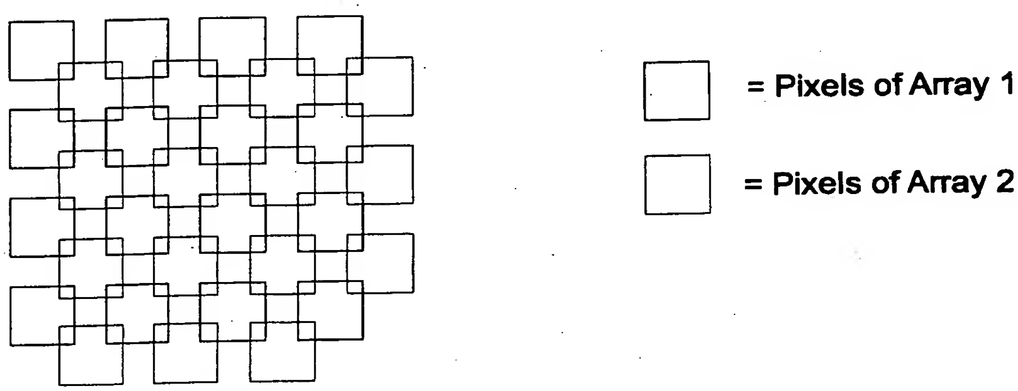

Figure 4

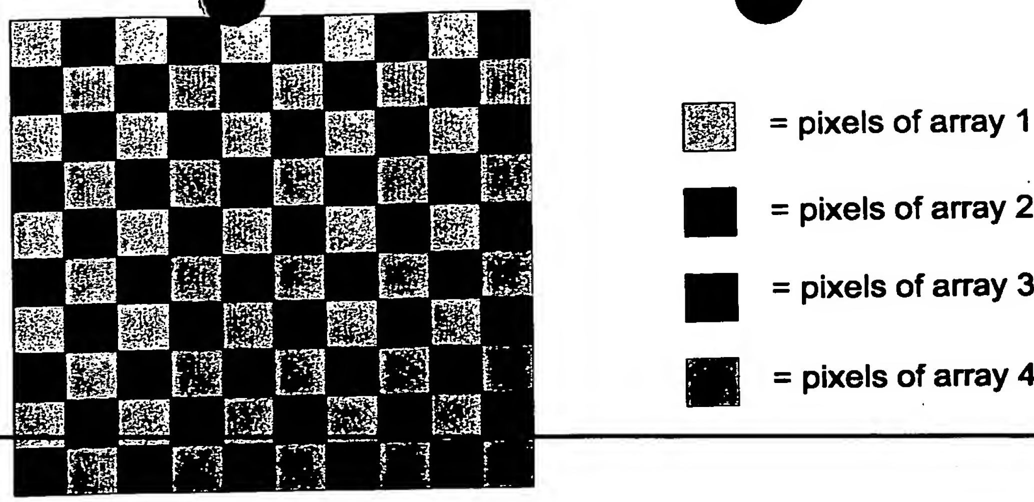

Figure 5

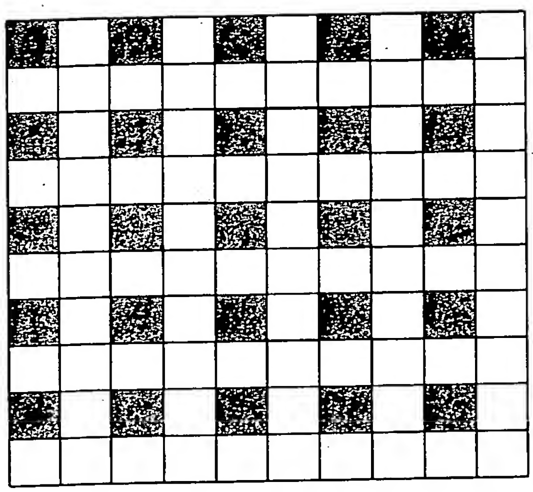

Figure 6

Figure 7

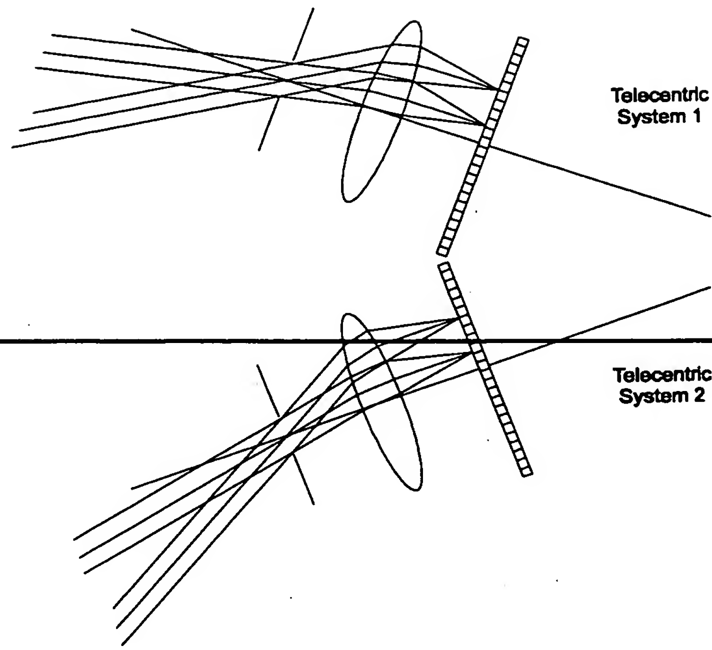

Figure 8